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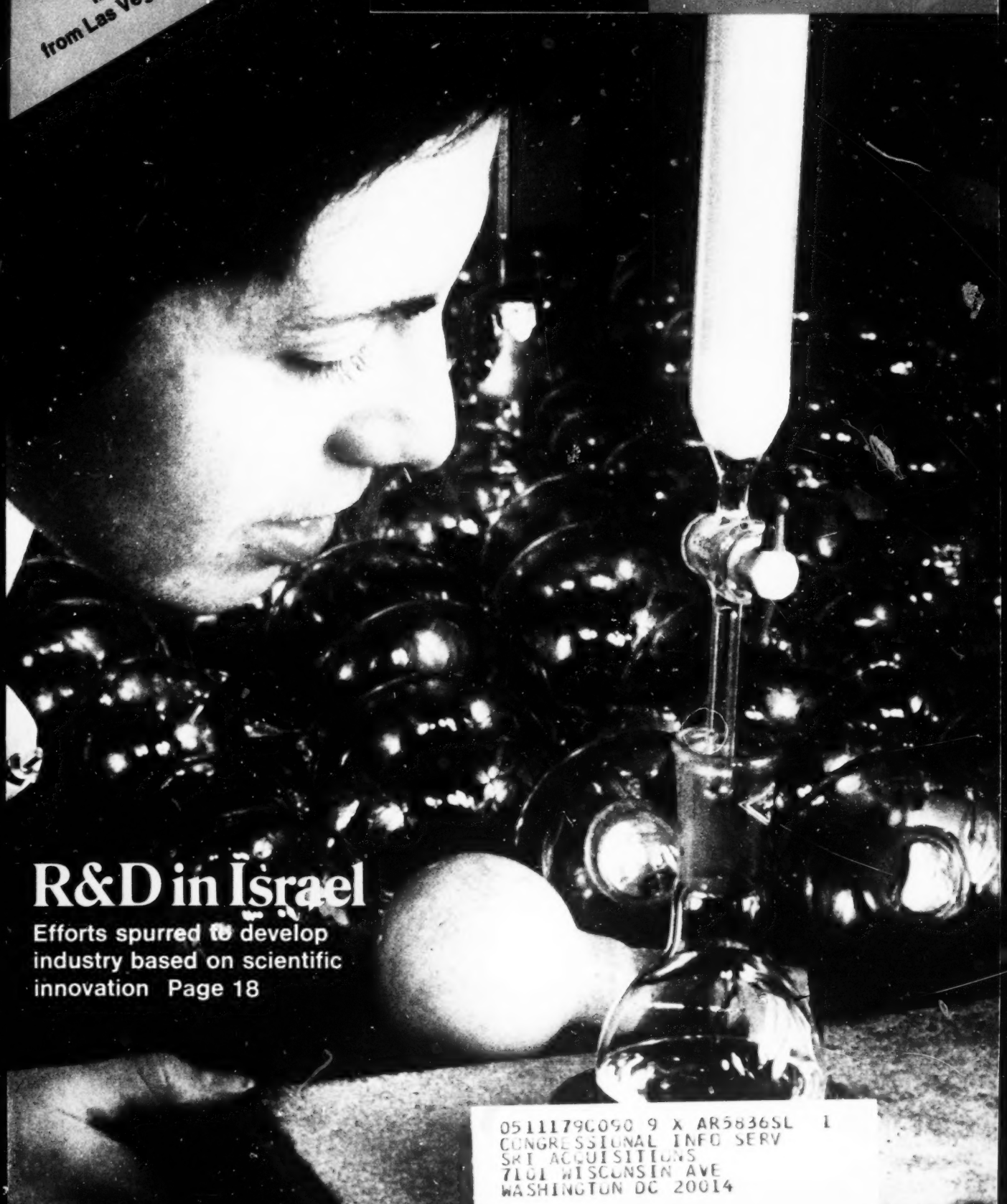
Chemical & Engineering NEWS
September 8, 1980

More scientific news from Las Vegas chemical congress



R&D in Israel

Efforts spurred to develop industry based on scientific innovation Page 18

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Cover: Scientist carries out chromatographic separation at Weizmann Institute of Science, Rehovot, Israel. (Weizmann Institute photo, supplied by courtesy of Embassy of Israel, Washington, D.C.)

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U.S. CHEMICAL INVESTMENT ABROAD RISING

Last year U.S. chemical companies increased their investments outside the U.S. more than foreign companies raised their chemical investments in the U.S., according to surveys by the Department of Commerce.

Specifically, U.S. chemical companies hiked investments to $19 billion overseas in 1979, an 18.5% increase over 1978. At the same time, foreign companies increased their chemical investments in the U.S. 16.2% to $7.1 billion.

By the end of 1979, U.S. chemical companies' investments abroad made up 9.9% of all U.S. overseas investments. Foreign investments in U.S. chemicals accounted for 13.5% of all foreign investments in the U.S.

Growth of U.S. chemical investment abroad outpaced that of total U.S. investment overseas, which rose 14.8% to $193 billion in 1979.

Both U.S. investment in chemicals and total investment abroad were highest in Western Europe, according to the Commerce Department. U.S. chemical investment in Europe rose 24.1% last year to $9.8 billion, total U.S. investment there rose 17.1% to $81.5 billion.

Even though increases in U.S. chemical investment abroad were large, U.S. oil company investments overseas were larger still. U.S. petroleum firms increased their total overseas investments to $41.6 billion by the end of 1979, a 23% rise from 1978. These firms' investments in Europe also increased nearly 23% to $18.6 billion.

U.S. chemical companies' money outflows in equity and intercompany accounts for foreign operations decreased 37.2% in 1979 to $715 million. Most of this—$473 million—was from Europe. Outflows in equity and intercompany accounts for all U.S. firms' foreign operations increased 21.1% in 1979 to $5.9 billion.

Reinvested earnings at U.S. chemical firms' foreign operations rose about 68% to $2.2 billion in 1979. The biggest such increase was in Canada, where reinvested earnings rose 254% from 1978 to $350 million. Reinvested earnings for all U.S. companies' foreign operations increased nearly 61% to $18.4 billion.

Income derived from U.S. chemical companies' foreign operations also showed a healthy increase in 1979. It rose 57.6% from the year before to $3.2 billion. Again, the bulk of this came from Europe—$2.0 billion, a 76.2% increase over 1978. However, th largest percentage occurred in Canada, where U.S. chemical income jumped 116% to $516 million.

On the other hand, foreign companies' income from U.S. chemical operations increased 13.2% in 1979 to $430 million. This is considerably lower than the 43% increase in income from total U.S. investment of foreign companies.

Money outflow in equity and cash accounts for the U.S. chemical investments of foreign companies decreased 6.4% in 1979 to $743 million. And reinvested earnings increased 27% to $234 million. □

Chemical investment overseas rose 18% in 1979, while foreign investment in U.S. chemicals increased 15%

$ Millions	Cumulative investment at year's end		Outflow[a]		Reinvested earnings[b]	
	1979	1978	1979	1978	1979	1978
U.S. DIRECT INVESTMENT ABROAD						
All areas	**$192,848**	**$167,804**	**$5904**	**$4877**	**$18,414**	**$11,469**
Petroleum	41,553	33,790	2730	412	4,979	1,355
Chemicals	18,990	16,026	715	1139	2,224	1,321
Europe	**81,463**	**69,553**	**1246**	**2447**	**10,522**	**5,665**
Petroleum	18,555	15,122	439	726	2,947	213
Chemicals	9,776	7,876	473	355	1,411	785
Canada	**41,033**	**37,071**	**915**	**−600**	**2,884**	**1,724**
Petroleum	9,168	8,246	5	−437	828	564
Chemicals	3,248	2,875	24	394	350	99
Latin America	**36,834**	**32,662**	**1454**	**2204**	**2,589**	**2,096**
Petroleum	4,568	3,892	38	218	623	187
Chemicals	3,632	3,250	98	277	284	300
FOREIGN INVESTMENT IN U.S.						
Total	**$52,200**	**$42,471**	**$5984**	**$5313**	**$3,729**	**$2,583**
Petroleum	9,903	7,762	526	303	1,615	940
Chemicals	7,081	6,094	743	794	234	184

a Equity and intercompany accounts. b For incorporated affiliates. Note: Negative number means net inflows to U.S.
Source: Department of Commerce

Thermodynamic data bank now available

In a move to help quench industry's thirst for reliable and badly needed standard reference data, the Thermodynamics Research Laboratory (TRL) at Washington University, St. Louis, has just released an extensive data bank containing thermodynamic data on pure compounds. In preparation for the past decade, the data bank is part of the laboratory's correlation package, a thermodynamic data system that also will include data on mixtures.

TRL director Buford D. Smith says that the data banks are the result of combing through 25,000 literature documents, collecting, processing, and critically evaluating the data, and organizing them on computer tape.

The data system is an ongoing project that is far from complete, however. The released data bank covers only 383 hydrocarbons in the C_3 to C_9 range. Entries for these include pure compound constants, such as melting and boiling points and critical properties; vapor pressure, liquid density, and second virial coefficients as a function of temperature; and equation of state data. The pure compound data bank will be updated every six months as new compound classes are added. Alcohols and ketones, for instance, are slated for inclusion in the data bank soon. Other types of data, such as heat capacities and heats of formation, will be added shortly; data on transport

Chemical stocks are still a bargain

For many chemical firms, however, stock prices are beginning to overtake book values; result may be a slowing in merger activity

It is little wonder that chemical companies are attractive takeover targets. Profitability generally outpaces the average for all manufacturing. Labor costs are relatively low in terms of other industries. There is enough of a countercyclical nature to the product mix that there are not the wild swings in earnings performance that occur in autos or construction. And chemical companies are very cheap.

For some time now, the price of the stock of many chemical companies has not kept pace with the book value of these companies. Book value is the assets of the company minus the liabilities; it is, in effect, the theoretical liquidation value of the company. Thus, if a company that has a stock price lower than its book value per share were to be liquidated, stockholders would make more money than they would have had they sold their stock. When an acquiring company buys a firm with a stock price lower than book value, it is buying assets at a greatly reduced price.

For instance, Union Carbide's stock on Aug. 27 closed at $46.75 per share. This is $21.66 below its book value per share of $68.41 at the end of the company's second quarter. Put another way, its stock price to book value ratio on Aug. 27 was 0.68 or 68%.

During the past year chemical companies' rating on Wall Street has improved. The stock price/book value ratio has climbed for a group of 20 companies surveyed by C&EN. On July 31, 1979, the median stock price/book value ratio for these 20 companies was 0.95. By the same date in 1980, the median ratio had climbed to 0.97. And by Aug. 27, the median actually hit 1.00. In other words, on that date the shares were selling at their liquidation values.

The average stock price/book value ratio looks better than the median for the 20 companies. On July 31 last year, the average ratio was 1.18. A year later it had risen to 1.35. And on Aug. 27, it was 1.44. This average was in part raised by increasing stock prices, but it was paced by some smaller chemical companies on the list such as Petrolite and First Mississippi.

Petrolite had a stock price/book value ratio on Aug. 27 of 4.59; First Mississippi a ratio of 3.61. Others with stock prices exceeding book value include Nalco Chemical with a ratio of 2.95; Air Products, 2.05; Mallinckrodt, 1.57; Diamond Shamrock, 1.42; Dow Chemical, 1.38; W. R. Grace, 1.25; Du Pont, 1.16; and Rohm & Haas, 1.02.

In all cases, in the past year book value for the companies surveyed has risen. But the stock price in general has risen much faster. The runup in chemical stocks in the past few months (C&EN, Aug. 18, page 6) means that the ratio has risen. However, there still are many companies that are greatly undervalued and show a lot of potential for improvement. In fact, since the median on Aug. 27 was 1.00, exactly half of the 20 companies surveyed have a stock price/book value ratio of less than 1.00.

The company with the lowest ratio is Hercules at 0.47 followed by Olin at 0.64, Carbide at 0.68, Monsanto at 0.69, Celanese at 0.72, and Pennwalt at 0.80. The rest of the companies below 1.00 fall in the 0.90 to 1.00 range.

The outlook for the companies' valuations is good, barring some untoward event such as double dip recession. With the stock market in general moving up and with chemical stocks outperforming the total market growth, the stock price/book value ratio for chemical companies probably will continue to increase.

Thus, chemical companies will become less attractive as takeover targets on a strictly price basis and, when takeovers do occur, it will not be because a company can acquire greatly undervalued assets.

William Storck, New York

Stock price had risen to firms' liquidation value near end of August

	Book value per share[a]		Stock price			Stock price/book ratio		
	Second quarter 1980	1979	Aug. 27, 1980	July 31, 1980	July 31, 1979	Aug. 27, 1980	July 31, 1980	July 31, 1979
Air Products	$22.72	$19.36	$46 1/2	$45	$34 7/8	2.05	1.98	1.80
Allied Chemical	57.05	46.08	53 1/4	51 1/4	35 5/8	0.93	0.90	0.77
American Cyanamid	28.91	27.20	27 1/2	28	25	0.95	0.97	0.92
Celanese	74.54	69.33	53 5/8	53	45 1/4	0.72	0.71	0.65
Diamond Shamrock	21.78	18.13	31	31 5/8	24 7/8	1.42	1.45	1.37
Dow Chemical	25.44	20.20	35 1/8	36 1/2	28	1.38	1.43	1.39
Du Pont	38.69	35.36	45	43	40 7/8	1.16	1.11	1.16
Ethyl Corp.	32.23	28.98	30 1/2	31 3/8	28 3/8	0.94	0.97	0.98
First Mississippi	13.14	8.39	47 3/8	40 3/4	15 1/8	3.61	3.10	1.80
W. R. Grace	35.29	32.74	44 1/8	43 3/4	30	1.25	1.24	0.92
Hercules	44.61	40.46	21	19 1/4	20	0.47	0.43	0.49
Mallinckrodt	24.67	23.16	40 1/4	36 1/2	28 1/2	1.57	1.42	1.23
Monsanto	80.63	75.76	55 3/4	55 3/8	52 1/4	0.69	0.69	0.69
Nalco Chemical	14.05	12.20	41 1/2	40 1/2	32 3/8	2.95	2.88	2.65
Olin	32.40	30.31	20 5/8	20 1/8	22 7/8	0.64	0.62	0.75
Pennwalt	37.26	35.24	29 3/4	29 3/4	32	0.80	0.80	0.90
Petrolite	17.23	15.11	79	65	47	4.59	3.77	3.11
Rohm & Haas	52.82	46.77	53 5/8	47 3/8	43	1.02	0.90	0.92
Stauffer Chemical	20.86	18.84	20 1/4	19 7/8	23 1/4	0.97	0.95	1.23
Union Carbide	68.41	58.67	46 3/4	43 3/4	40 5/8	0.68	0.64	0.69
MEDIAN						1.00	0.97	0.95

a Stockholders' equity divided by number of shares of common stock outstanding.

Israel spurs development of industrial R&D

Richard J. Seltzer
C&EN, Washington

"There will come an age of small and independent nations whose front line of defense will be knowledge." ***(Charles P. Steinmetz, 1865–1923)***

"Moses made a wrong turn while he was leading the Children of Israel through the wilderness toward the Promised Land. If only he had turned right, toward the Persian Gulf—instead of left, toward the Mediterranean! We could now be floating in oil!" ***(current Israeli joke)***

Nothing could be more relevant to the situation of the state of Israel since its founding in 1948 than these words from electrical pioneer Steinmetz or this popular Israeli joke.

Sited at the heart of the critical and explosive Middle East, Israel is beleaguered by heavy economic, social, political, and military pressures. In confrontation with its neighbors except for a fragile new peace treaty with Egypt, strained by an economy with an inflation rate of 111% last year and a government budget devoting about a third to defense and almost another third to debt service, beset by the problems of integrating previous immigrants from African and Asian lands with low educational levels and of absorbing new immigrants from the U.S.S.R. and other developed lands with high educational levels, Israel is par excellence a small nation whose front line of defense and future growth and welfare depend critically upon knowledge—particularly scientific and technological knowledge.

Moreover, there is an important point to the joke about Moses' "wrong turn," wryly related in different versions to a recent visitor to Israel by several leading Israeli scientists and science administrators. The point is that Israel imports most of its fuel supplies—putting a soaring burden on its balance of payments—and has few other natural resources. (Fuel imports are expected to cost about $2.4 billion this year.) Its only sizable resources are salts from the Dead Sea, phosphates, and the sun.

"The main natural resource that we have is brain power," they stress, "so we have to rely on this to make our way in the world."

In fact, perhaps no relatively new and developing country has made science and technology so central an element in its development strategy—and indeed its survival. In particular, the two outstanding successes have been development of efficient, science-based agriculture and creation of a highly sophisticated, R&D-based defense establishment.

Now science is being called on to do the same for industry. Israel gives top priority to expanding industry in its current efforts to reduce its huge foreign trade imbalance (about $3.8 billion in 1979) and to lessen its economic dependence on foreign loans and grants. And the type of industry that Israel must nurture, officials stress—with high export potential, high added value, a minimum of raw materials, and maximum exploitation of the country's highly skilled but relatively low-cost manpower—is industry based on science and high technology in chemical and other areas.

"All of us realize that the future of our industry is in technological innovation," emphasizes Arieh Lavie, chief scientist at the Ministry of Industry, Trade & Tourism. "This is the main advantage that we have in this country for our industry. We don't actually have any other advantage."

This has led to several results:

- An intensifying government effort to promote R&D with industrial potential at Israel's research labs, both in industry and in academia.

Efforts mount to promote industry based on scientific innovation; balance shifts from basic toward applied research

At Desert Research Institute in Sdeh Boker, Aharon Abelovich checks algae-growing ponds

- Successful development of science-based industry in electronics, certain chemical-related areas, and other fields.
- A start at shifting the center of gravity of Israel's scientific community from basic research to applied and industrial research, propelled by government funding policies.
- Development at Israeli labs of a number of new ideas with commercial potential, some already drawing interest and involvement by foreign firms.

Israel has built up a world-class research establishment in its 32 years, with pioneering achievements in a number of fields. It currently spends about $300 million (about 2% of its gross national product) on civilian and military R&D together, about 53% of this for civilian R&D. This is comparable to R&D spending by the U.S. (2.3% of GNP) and other developed countries.

Moreover, relative to its population of about 3.8 million, Israel has more scientists and engineers engaged in R&D than do the U.S., Japan, or West European countries. More Israeli scientists publish papers in international scientific journals, relative to their nation's population, than do scientists of other lands. And in 1975, the latest year for which figures are available, Israel awarded more master's and doctorate degrees in the

C&EN staff photo

natural sciences, relative to population, than any other country.

However, Israel's high rate of scientific publication reflects another characteristic besides research productivity—an "inverted pyramid" structure for Israeli science. Other countries generally have a broad foundation of scientists working at applied and industrial R&D, with a smaller basic research apex. Israel has had just the opposite, with most of its scientists working on basic research at academic institutions (and hence more prolific at publishing papers).

Thus, in 1972–73 Israeli industry carried out only 18% of all civilian R&D. Academic institutions did 61%, government research institutes did 19%, and hospitals 2%. Industry carried out even lower fractions of the R&D in previous years.

This inverted pyramid has existed since before Israel became independent in 1948. Israeli science started with establishment of universities and research institutes, in particular three major institutions: Technion-Israel Institute of Technology in Haifa and Hebrew University of Jerusalem in the 1920's, and Weizmann Institute of Science in Rehovot in the 1940's. (Weizmann Institute, formally established in 1949 as primarily a basic research institute, grew out of Daniel Sieff Institute, which was founded as a largely applied research institute in 1934 by Chaim Weizmann, a leader of the Zionist movement and a noted chemist, later first president of Israel.)

These three institutions have been joined since by four more universities—Tel Aviv University and Bar Ilan University in the 1950's, and Ben-Gurion University of the Negev and University of Haifa in the 1960's. A scientific elite grew up that did high-prestige basic research and that in many cases looked down with disrespect on applied research and industry. There was relatively little academic-industrial communication or collaboration.

The other side of the coin was a dismal scene for R&D and innovation in industry. With a few exceptions, industry was based on technology readily available or bought abroad—what one Israeli science administrator, Zvi Pelah, director of the R&D Authority at Ben-Gurion University, describes as "simply filling bottles." Industry was mostly too small and unsophisticated to carry out R&D, and industrial managers did not have the background or orientation to appreciate what R&D could do for them. (Among the exceptions was work on exploiting Dead Sea salts and on use of solar collectors for home water heating.)

For many years, Israelis have talked about the need to change this situation, and to focus their high-powered scientific establishment to a much greater degree on Israel's practical economic needs, particularly industrially oriented R&D. Now, by all indications, they finally have begun to do it.

The change during the past few years is dramatic, as shown in three sets of figures cited by Lavie. In 1973, only about 19% of Israel's civilian R&D spending was devoted to industrial R&D, compared to rates of 60% in the Netherlands, 70% in the U.S., and 80% in Switzerland. However, this year close to half of Israel's civilian R&D is in industrially related areas. And Israel aims to raise the balance to 60% industrial research, and 40% basic research.

Moreover, Lavie explains, industrial exports resulting from Israeli R&D have soared more than 30% a year in recent years—from $349 million in 1976 to $783 million in 1979.

Israel sets goals for rapid growth in industrial R&D

Israel has put R&D at the center of its ambitious plans for development of industry, including chemical industry, during the next decade. Top priority thus goes to beefing up industrial R&D, previously underdeveloped in Israel, including:

- Increased spending on industrial R&D, going from about $6 million in 1970 to about $70 million in 1979 (exclusive of buildings and equipment).
- Shifting the balance between industrial and academic research, with industrial R&D rising from 19% of civilian R&D spending in 1973 to about 50% this year and a goal of 60% in the next few years.
- Rapid growth in industrial exports based on Israeli R&D, from about $20 million in 1972 to $783 million in 1979 and a projected $4 billion by 1990—going from 4% of all industrial exports in 1972 to 31% in 1979 and close to half by 1990.
- More than tripling the number of R&D scientists and engineers in industry, from 1438 in 1975 to 4870 by 1983, including an increase in chemists and chemical engineers from 341 to 1120.

This includes both locally developed products and exports produced using locally developed processes, such as heavy chemicals. Last year, about one third of Israel's industrial exports of $2.5 billion (excluding processed diamonds) resulted from local R&D, compared to only 4% of industrial exports as recently as 1972. The goal is to increase exports based on local R&D to $4 billion by 1990 (about half of all industrial exports).

Manpower figures also demonstrate the trend, Lavie adds—and the major place given to chemical R&D. Israel has about 10,000 scientists and 20,000 engineers, he notes. Of these, 2580 worked on R&D in industry in 1979, including 410 chemists and 210 chemical engineers (plus about 400 additional scientists and engineers doing industrially oriented research at research institutes and universities). These figures represent an increase of about 80% in both cases from those doing R&D in industry in 1975 (1438 total scientists and engineers in 1975 and 341 chemists and chemical engineers). The aim is to increase R&D scientists and engineers about 16% a year to 4670 by 1983, including 750 chemists and 370 chemical engineers.

Young scientists now are much more willing to work on applied and industrial research than 10 or 15 years ago, adds Ephraim Katchalski-Katzir, a noted chemist and former president of Israel. They are beginning to realize that applied research can be of great interest and can be done at a high scientific level, he explains. In addition, there are now only very limited positions open for doing basic research.

Israel is developing a variety of mechanisms to encourage industrial R&D and innovation, and some Israelis believe that their methods may be useful for other developing countries. A central role in funding and coordination is played by the Office of the Chief Scientist that Lavie heads at the Ministry of Industry, Trade & Tourism. The office has a research fund that will spend about $40 million this year to support some 600 R&D projects at about 300 Israeli firms, as well as about 200 long-range projects at research institutes and universities.

The fund has doubled in size during the past three years, and supplies about half the industrial R&D funding in Israel. (Industry supplies the other half.) One survey of its effectiveness showed an increase of about $9.00 in industrial exports during 1972–76 for each dollar in grants in 1970–74. Most of the industrial R&D is done in company labs, with some subcontracting to academic labs.

Grants are given by Lavie's office for 30 to 100% of the costs of R&D projects. The office gives 50% of costs when the product or process is intended primarily for export and the market has been clearly demonstrated. (Most approved projects fall into this category.)

It gives up to 80% for what are called "national projects" or "projects of national importance"—when the size, importance, potential return, and greater technological risk warrant greater government participation. Eighteen such projects have been approved so far.

The office gives 100% support for research at academic labs to provide fundamental information for industrial development. "Preindustrial R&D" projects also can be supported through a newly created joint fund between the office and the universities, until the projects reach the stage of industrial interest. And up to 30% support is given industrial R&D projects designed to replace imported products with locally produced goods of equal or better quality.

Firms that are successful in developing a commercial product from a supported R&D project return the original grant amount plus interest to the office's research fund by paying a royalty of 1% on sales of the product. (National projects pay 2% royalties.)

Two constraints that Israel faces in developing innovative products for export are the small local market—which can serve at best as a "piloting market" for most innovative products—and the relatively small size of Israeli firms compared to huge companies they must compete with in foreign markets.

However, Lavie notes, small firms often have the advantages of technical resourcefulness, flexibility, and quick response to test results and market opportunities, and Israel tries to encourage this. Lavie's office has enabled even very small firms to carry out R&D. Such support also shares and thus lessens the risk that an R&D investment, if unsuccessful, will wipe out a small firm.

For example, he cites three small Israeli firms producing computerized numerical control equipment, employing only 20 to 40 people each. The firms already have exports of $1 million to $3 million a year each, and are increasing exports at the rate of 300% a year.

Another small firm with some 60 employees, Dexter Chemical Corp. (a subsidiary of a small U.S. firm of the same name based in the Bronx), is a multimillion-dollar exporter of auxiliary chemicals for textile processing, and is one of seven winners of the most recent annual Israeli export prizes. Breaking into a new field, the Israeli firm now is doing R&D on pheromones for possible control of a cotton pest and other insects. Six pheromones look most promising.

However, Lavie points out, it is very difficult for small firms to learn about and to penetrate markets abroad. Israel does not want just to sell the rights to its innovations to foreign firms, but rather to have at least the first production plant built in Israel. So cooperation with other countries—joint R&D, joint ventures, investments, and other relationships—is seen as extremely important, particularly for the marketing tools it supplies. The Ministry of Industry, Trade & Tourism tries to promote such cooperation through loans, grants, and other incentives. Another inducement to non-European firms is duty-free entry for Israeli-made industrial products to the European Common Market under an agreement in effect since 1977.

Indeed, the pheromone project has become a joint venture with a large

R&D supplies growing share of Israel's industrial exports . . .

$ Million	Industrial exports based on local R&D[a]	All industrial exports[b]	% based on local R&D
1972	$ 20	$ 527	4%
1973	101	626	16
1974	233	928	25
1975	290	970	30
1976	349	1228	28
1977	433	1551	28
1978	513	1923	27
1979	785	2545	31
1985[c]	1000	3250	31
1990[c]	4000	na	na

a Includes both locally developed products and exports produced using locally developed processes, such as heavy chemicals. b Excluding processed diamonds. c Projected. na = not available. Sources: Israeli Ministry of Industry, Trade & Tourism, and Government of Israel Trade Center

. . . and chemical industry supplies almost one third

$ Millions	Chemical exports	% of all industrial exports[a]
1972	$134	25%
1973	161	26
1974	349	38
1975	321	33
1976	342	28
1977	442	28
1978	528	27
1979	726	29

a Excluding processed diamonds. Source: Israeli Ministry of Industry, Trade & Tourism.

Foundation promotes joint R&D by U.S., Israeli firms

"There are some real technological bargains in Israel—real talent, capabilities, and a lot of ambition. So our funding is not a handout—it's a vehicle for supporting programs of mutual benefit."

In this enthusiastic way, A. I. "Eddie" Mlavsky describes his work as the executive director of the Israel-U.S. Binational Industrial R&D Foundation (BIRD F) to a visitor to his office on the outskirts of Tel Aviv. In days of lagging U.S. industrial innovation and productivity, there is special interest in this unique attempt by the U.S. and a foreign government to promote joint R&D by firms in their countries.

"There are some very sophisticated companies in Israel, but there are also some very small companies just starting up," Mlavsky notes. "I'm an old Rte. 128 man, myself," he says, citing the small science-based firms that started in the 1950's and 1960's along Boston's suburban belt highway. (Mlavsky is on leave from the executive vice presidency of Mobil Tyco Solar Energy Corp., located near Rte. 128 in Waltham, Mass., which is developing photovoltaic cells.) "And this reminds me of it—a lot of young guys with concepts and daring, some not too knowledgeable on marketing" or on how to commercialize a product. "So we ask people for their commercialization plan, as well as their technological startup plan. It's a good disciplinary measure for companies."

BIRD F was formally established in 1977, he points out, but only started sponsoring projects about a year ago. It is the only institution of its kind between the U.S. and another country—and probably the only one between any two countries—explain Mlavsky and David A. Guberman, a special assistant to assistant secretary of Commerce Jordan J. Baruch, who monitors BIRD F for the Commerce Department. (The U.S. has had indications of interest in similar programs from other countries, such as Egypt and India, Guberman says, but is waiting for more experience with Israel before deciding on additional programs.)

C&EN staff photo

Mlavsky: technological bargains

BIRD F was started with an endowment of $60 million, approximately half from each country's government, and its board consists of three senior government officials from each country. The annual income on the endowment, about $2.6 million in the past year, is used to aid projects between U.S. and Israeli for-profit firms, typically paying 50% of costs up to a maximum of $250,000 a year, for up to three years. One-year awards of up to $100,000 are also given for testing technical and market feasibility.

Support can cover all stages, from lab exploratory research to test marketing, as long as R&D is the main component. Recipients agree to pay BIRD F if their project is commercially successful. Proprietary information is kept confidential, and any patents belong to the firms involved, with a royalty going to BIRD F.

The foundation expects to have 20 projects under way by the end of the year, and its board is exploring ways of increasing its funding capabilities. This is especially important because the original $60 million endowment has shrunk to less than $40 million through devaluations of the Israeli currency.

Current projects include medical electronics, advanced communication equipment, computer software, solar energy (developing a system for generation of industrial process heat and steam), and agrotechnology (for example, computerized irrigation systems)—in all of which Israel has state-of-the-art capabilities. A project under consideration involves pharmaceutical development.

Under one project, clinical testing is being done on an ovutimer, a device pinpointing the exact day of a woman's ovulation by measuring the viscosity of her vaginal mucus. This involves Elron-Iscar Biomedical Instruments Ltd. of Haifa and Ovutime Inc. of Brookline, Mass. And a joint project by Israel Chemicals Ltd. of Tel Aviv and General Refractories Inc. of Philadelphia is developing a low-energy-consuming process for making high-purity magnesium oxide (periclase) from Dead Sea salts for use in refractory bricks to line steelmaking furnaces.

One problem is that the foundation is not yet well known in the U.S., Mlavsky says. He especially hopes to attract more interest from medium- and smaller-sized firms, with annual sales of a few million dollars to $100 million. He considers such firms most suitable for joint ventures: Their size is closer to that of Israeli firms; participation in a BIRD F project can significantly increase the R&D funding, technology, and talent available to them; and it can greatly enhance their opportunities for foreign sales.

U.S. chemical firm not previously active in Israel, whose name is being withheld from publication at present. The Israeli side will continue R&D and will produce the pheromone; the U.S. chemical firm will explore marketing and the logistics and equipment for aerial spraying over large areas.

Overall, more than 150 foreign firms cooperate in various ways with Israeli firms, including more than 20 joint ventures. Among them are 22 of the "*Fortune* 500" U.S. corporations. U.S. chemical and chemical-related firms include Monsanto, Pennwalt, Baxter Travenol Laboratories, Witco, Miles Laboratories, Revlon, General Refractories Co., Sigma-Aldrich Corp., Philipp Brothers Chemicals, and Belco Petroleum Corp.

In addition, about 20 projects involving joint R&D by U.S. and Israeli firms will be funded by the end of this year by the Israel-U.S. Binational Industrial R&D Foundation (BIRD F). Establishment of similar foundations between Israel and other countries is being discussed. And a new company has been set up in the U.K. to promote cooperation between Israel and the U.K. and other European and Commonwealth countries. (There also are U.S.-Israel foundations to promote joint nonindustrial research and agricultural research—the U.S.-Israel Binational Science Foundation and the U.S.-Israel Binational Agricultural R&D Foundation.)

Whenever the subject arises of cooperation and investment by foreign firms in Israel, a question inevitably follows: How effective is the Arab boycott of Israel and of firms that have links to Israel?

There is "no doubt," acknowledge Lavie and A. I. Mlavsky, executive director of BIRD F, that some U.S. and European firms are inhibited by fear of the Arab boycott from starting ties with Israeli companies. (U.S. firms will not admit this, particularly since some forms of cooperation with

Inorganics the strong point of Israel's chemical industry

Israel's chemical industry is now developing briskly. Its strong point so far is inorganics, according to David M. Vofsi, head of the Center for Industrial Research at Weizmann Institute. Vofsi took a leave of absence in 1974–75 to serve for a year as director of research at Makhteshim Chemical Works Ltd. in Beersheba, and keeps in close touch with the chemical industry.

Dead Sea Works Ltd. exports about 1.2 million metric tons a year of potash, Vofsi notes, and is stepping up its capacity to 2 million (targeted for completion by the end of 1981). About 2.5 million metric tons of enriched phosphate rock are exported annually. And some 60,000 metric tons a year of bromine are produced from the Dead Sea, with $70 million in exports of bromine and bromine compounds. Israel is second to the U.S. in world bromine production.

One focus of considerable effort now at Makhteshim and other firms is programs to convert this large bromine supply into upgraded products, such as bromostyrene. A bromination process developed at Makhteshim, which Vofsi worked on, has passed the pilot-plant stage. A decision is imminent on construction of a plant to make thousands of metric tons a year of bromostyrene.

The Dead Sea also is the source (by conversion of magnesium chloride to magnesium oxide) of 50,000 metric tons a year of high-grade periclase for use in refractories, such as steel mill furnace brick linings. Essentially all of this production is exported, yielding $25 million a year.

There are two large producers of herbicides, fungicides, and insecticides—Makhteshim and Agan Chemical Manufacturers Ltd.—both belonging to Koor Chemicals Ltd., the chemical division of Israel's large industrial conglomerate, Koor Industries. The two firms export about 80% of their production, including to the U.S.

Israel's pharmaceutical industry is gaining momentum now, Vofsi adds. It is on the verge of converting from a generic, "me-too" type of industry—which concentrated on developing a better process or product for already existing drugs—to a maker of more sophisticated and original products of its own. The drawback, of course, he notes, is the great expense and long time to develop and test new drugs, especially to meet U.S. regulatory requirements.

Israel has almost no local petroleum and gas, and so its petrochemical industry is greatly affected by soaring world oil prices. It has a capacity of about 100,000 metric tons a year of polyvinyl chloride—at least 60% of which is exported—and makes a similar amount of low-density polyethylene. Israel also makes polystyrene, phenolic- and urea-formaldehyde resins, and polyesters for reinforced plastic.

C&EN staff photo

Vofsi: plastics from kibbutzim

In the synthetic fiber field, it makes the three most important basic fibers—nylon and nylon 66, polyterephthalate ester, and acrylics. It exports them only in the form of finished clothes. Israel does not make synthetic rubber, but imports and compounds it locally.

Interestingly, Vofsi observes, the center of the plastics fabricating industry is in Israeli kibbutzim (collective agricultural settlements). It is very appropriate because it is nonpolluting, does not require heavy investment, supplies jobs for older and handicapped people who cannot work in the fields, and is in some cases connected with agriculture. Among the products: highly sophisticated plastic irrigation components, plastic eyeglass lenses, and injection-molded plastic crates for gathering crops. Recently, Vofsi met with some kibbutz members, including a chemical engineer, to discuss possible production of contact lenses.

The Weizmann chemist stresses that Israel's future lies in developing the most sophisticated chemical areas—chemicals selling for $5000 to $50,000 or even more a metric ton—rather than trying to compete in low-priced chemicals, especially where Israel lacks raw materials. Thus he would focus on flame retardants; pesticides, pharmaceuticals, medical diagnostics, vaccines, biomedicals, and other specialty-type chemicals. As for Israel's bulk inorganic chemical products, he says, the future depends on the costs of transportation and of energy for processing. (For instance, a canal from the Mediterranean to the Dead Sea, recently approved in principle by the Israeli government, would produce hydroelectric power.)

the boycott are against the law, notes Mlavsky.)

Many of the foreign firms that establish links do not want their names publicized because of commercial reasons as well as the Arab boycott, points out Philip K. Isaacs, chief technologist and coordinator of international R&D in Lavie's office. However, he continues, "I think it's significant that some of these companies, even though they say outright that they don't want their names used, come anyway."

In summary, stresses Lavie, "We don't see that this [the boycott] is really a main obstacle when we speak of technology. But this is an obstacle, and we shouldn't underestimate it."

R&D supported by Lavie's office covers a wide variety of fields, including agrotechnology, water desalination, electronics and medical electronics, communications systems, minicomputers, solar collectors, and textile machinery. Chemical-related projects take a major share, numbering 45% of total industrial R&D projects in Israeli fiscal year 1978–79 (beginning April 1, 1978) and receiving 32% of the money. Only electronics got more funding, 48% of the total. (These figures do not include national projects, BIRD F projects, or long-range projects at academic labs, which also have a high chemical component.)

Chemical R&D projects include work on: new pesticides; fire retardants; nitrogen-phosphorus-potassium fertilizers (Israel has sizable resources of phosphates and potassium); new compounds from bromine and magnesium; anticorrosion pigments; ceramic products; lubricant additives; pharmaceuticals, including development of new medicines based on plant, animal, and marine sources; clinical chemical diagnostic kits, particularly radioimmunoassay kits; fine chemicals for research; enzymes for food and other industrial processes; and preparation of a food sweetener and of aromatic and dye additives from citrus fruit peels.

Israel's chemical industry already contributes almost half of the country's industrial exports based on local R&D. Total chemical, rubber, plastics, and oil products exports reached $726 million in 1979, up 38% from 1978. The industry plans to double chemical exports by 1988.

The push for industrial R&D and science-based, export-focused industry in Israel already has produced several success stories frequently cited as models for future development. One is the Haifa-based Elron Electronic Industries group of companies, founded in 1957 as a "garage operation," which now has more than

3000 employees, including about 800 engineers and scientists. The founder and president, Uzia Galil—sometimes called the founder of science-based industry in Israel—says he expects more than $90 million in sales this year (compared to $70 million last year).

The Elron group has developed computer equipment and systems, electronics, and medical and nuclear medical instruments (including a computerized tomography system), and is now moving into fiber-optics and orthopedic implants. The firm has joint ventures with several foreign companies.

A second firm is Ames-Yissum Ltd., founded in 1968 as a joint venture by Miles Laboratories of the U.S. and Hebrew University's Yissum Research Development Co. The idea was to commercialize the results of university research, particularly development of medical diagnostic systems.

Ames-Yissum, located in the university's industrial park for science-based industry in Jerusalem, currently makes 10 different thyroid function diagnostic test kits, plus a number of other tests. Ninety-seven per cent of production was exported last year and sales were $2.3 million (50% in the U.S.). The firm now is introducing thyroid function tests using new chromatography tubes and packings it has developed. It also is working on virology tests, and on nonradioactive alternatives to its current radioimmunoassay systems.

A third firm is Ormat Turbines Ltd., established in 1965, which has sold more than 3000 low-temperature Rankine cycle turbines all over the world, particularly for use in remote locations where low-maintenance electrical generating equipment is needed. For example, 122 turbines are being used on the Trans-Alaska Pipeline for telemetry and remote gate valves. Sales in 1979 were about $10 million. The firm also makes solar pumping systems and systems for producing power from industrial low-temperature waste heat and other low-grade heat sources.

Ormat now is testing a solar pond method of electricity production in a 150-kw pilot unit at Ein Bokek on the Dead Sea shore. According to the method, developed originally at Scientific Research Foundation in Jerusalem, salt is dissolved in the 7000-sq-m pond, building a density gradient rising in concentration from top to bottom. If the density gradient is sufficiently great, solar rays can penetrate the pond and heat the lower layers of water to about 80° to 100° C without any convection. The top, cooler layers act as an insulator,

C&EN staff photo

Lavie: righting inverted pyramid

as long as the pond is not stirred. Hot water then can be piped from the bottom, without disturbing the concentration gradient, into a Rankine cycle turbine using a low-boiling liquid, and electricity generated.

Use of the solar pond has two advantages: It is a large-scale, cheap solar collector without glass or metal; and it also stores the heat for use when needed, night or day. All the system needs is water, salt, sunshine, and available land. Ormat says the cost per kilowatt hour will be competitive with conventional and nuclear systems.

The firm plans to start up a 5-Mw unit next year—the first module of a possible 20-Mw or larger system. And it is conducting feasibility studies related to building a solar pond power-generating demonstration plant of 5 Mw in California, under contract to Southern California Edison Co.

As Israel's academic institutions have shifted to more applied research, they have undertaken a number of steps promoting their efforts. These include strengthening central offices to coordinate, administer, and help seek outside R&D funding; creating centers to bring together scientists from different departments for work on specific interdisciplinary problems (such as energy, the environment, drug research, or genetic engineering); and building up departments in applied science and technology (such as Hebrew University's School of Applied Science & Technology, and its component Casali Institute of Applied Chemistry).

The efforts also include infusion of more applied research into regular academic departments, establishment of companies to deal with industrial development of research findings, and inauguration of nearby industrial parks specifically for science-based industry, including spinoffs from academic research (inspired by the example of Boston's Rte. 128). Ben-Gurion University of the Negev particularly has taken on the goal of aiding development of the Negev, Israel's southern, largely desert region.

Questions are raised about how industrially oriented research should be done in an academic framework, and how industrial it should get. Different arrangements are being tried at different institutions. And one serious problem, according to several sources (others deny it), is that Israeli academic scientists who do applied research are not rewarded with pay and promotions equally with those following the standard basic research-journal publication route.

Who's Who in Israeli chemical industry

The largest chemical conglomerate in Israel is Israel Chemicals Ltd. (ICL), owned by the Israeli government. Active primarily in inorganic chemicals, firms in this group include the Dead Sea Works Ltd., Dead Sea Bromine Ltd., Bromine Compounds Ltd., Negev Phosphates Ltd., Fertilizers & Chemicals Ltd., and Dead Sea Periclase Ltd. Besides ICL, also active in inorganics and fertilizers derived from potash and phosphates is Haifa Chemicals Ltd.

Koor Chemicals Ltd. is another conglomerate. It includes, among others, Makhteshim Chemical Works Ltd. and Agan Chemical Manufacturers Ltd., which make crop protection products and chemicals for plastics and photographic industries. Another chemical group is the Dor-Carmel Group, which produces methanol, formaldehyde solutions, hydrogen, plastic molding compounds, resins, glues, and salt.

In the petrochemical area, there is Israel Petrochemical Enterprises Ltd., which makes polyethylene, carbon black, and polystyrene. Electrochemical Industries (Frutarom) Ltd. makes chlorine and caustic soda, polyvinyl chloride, and other chemicals, and its Frutarom division produces aroma chemicals, citrus oils, flavoring essences, and perfume fragrances. And two major producers of pharmaceuticals and fine chemicals are Teva Pharmaceutical Industries Ltd. and Abic Ltd.

Former Israeli president, returned to chemistry, surveys science and society

A unique vantage point on science and society in Israel and in the world has been gained by Ephraim Katchalski-Katzir. For 24 years head of the Department of Biophysics at Weizmann Institute of Science, Katzir was elected in 1973 to a five-year term as president of Israel—a nonpolitical and largely ceremonial office, but one important in promoting national values and unity.

Katzir, 64, has done pioneering work on synthetic polyamino acids and their use as protein models and on immobilized enzymes, and has won many international honors. He has been a central influence in shaping Israeli science and science policy, including three years as chief scientist at the Ministry of Defense. On becoming president, he changed his name, Katchalski, to the Hebrew name Katzir. He has now returned to full-time scientific work, and was interviewed by C&EN at Weizmann Institute.

Katzir (right) and Israeli foreign minister Shamir talk with Anwar Sadat

What role can a small country like Israel play in world science, considering its limitations in size and resources? "As far as basic research goes, our priority as a small nation should be to try to make original contributions," says Katzir. "It's more difficult for us to compete with big nations and with big centers of science in an area where there is rapid development and in which many scientists participate. We should be aware of all these areas and know the ideas and techniques," he adds. But Israeli scientists should avoid just jumping on the bandwagon and doing what is in fashion.

Another contribution that Israeli scientists can make to world science, Katzir believes, is bringing traditional Jewish values and ideals—many of them now embodied in the Judeo-Christian tradition—to consideration of moral and ethical questions involving science. One case in which Israeli scientists have had influence, he observes, is in helping to focus the attention of the world scientific community on Soviet mistreatment of some Soviet scientists, and on Soviet bars to free scientific travel and exchange.

The former Israeli president is quite pleased with, but also critical of, the development of science and technology in Israel. On the one hand, he says, Israel has accomplished a great deal in its basic scientific research and higher education, and the efforts have "paid off in many ways"—in defense, agriculture, metallurgy, electronics, small computers, and other areas.

In this, he believes, Israel is implementing the ideals and values of its founders. "For the last 2000 years, Jews have respected intellectual and spiritual activities. As a result of this type of activity, they were able to retain their integrity as a nation."

On the other hand, Katzir says, "I think that we have overemphasized basic research," at the expense of applied and industrial research. "There were times when most of our scientists were dealing with basic research."

In 1968 Katzir headed an advisory committee that issued an influential report—named after him "the Katchalski Report"—urging the Israeli government to step up efforts in applied and industrial research (without reducing basic research), and to reorganize its R&D activities. This resulted in establishment of chief scientists' offices in a number of government ministries to coordinate and support R&D in their respective areas, including industry, defense, agriculture, health, and energy.

The balance now has shifted so that about half of all Israeli civilian R&D funding is in applied areas, he notes. He says that "we're going in the right direction," and recommends a goal of 60% applied and 40% basic research.

However, he believes, there is now a threat of going too far in the opposite direction. Many Israeli government officials and political leaders consider the current amount of basic research "a luxury" Israel cannot afford with all its other pressing needs. Some political leaders suggest that it would be better to deal with Israel's social problems, by spending more money on kindergartens and less on research institutions.

However, Katzir emphasizes—"and this is what I tell all our ministers and Prime Minister"—that increasing applied R&D should by no means involve reducing basic research. "We'll never have applied research of high standards without having good basic research."

Another problem that concerns Katzir and other Israeli scientists, such as Dov Frohman-Bentchkowsky, director of the School of Applied Science & Technology at Hebrew University, is insufficient national science planning and coordination, and inadequate seeking of scientific advice in making government decisions. There is no central science adviser to the Prime Minister and cabinet, such as the White House has, and individual ministries vary in their solicitation of scientific opinion.

Individual ministries give R&D funds to industry, agriculture, or other areas independently, "without interaction or coordination," notes Frohman-Bentchkowsky. And there is no coordination by such ministries with the Ministry of Education & Culture on manpower needs.

Katzir believes that one solution is a proposal now under consideration to set up a committee of four or five ministers to deal with all R&D areas of general national importance, such as energy, water supplies, and manpower. He also favors establishment of a central science adviser to the government. And he hopes to renew, within the framework of the National Council for R&D, a group of scientists and engineers he organized while president to identify problems deserving national priority and advise the government.

For a long time, Katzir says, Israeli scientists and engineers have not concerned themselves sufficiently—or often at all—with the problems and needs of Israeli society. This situation is gradually changing, he adds.

However, he believes, this is a general problem all over the world caused by too narrow training of scientists and engineers. Teachers should include the impact on or importance to society of whatever material, process, or theory they teach, he stresses.

Science provides tools that change the lives of individuals and nations in far-reaching ways, the Weizmann chemist notes. Scientists understand better than laymen the possibilities and dangers of these tools. "So they are responsible as a group," and must be ready to advise society on what should be done and not be done.

"This does not mean that every scientist should be involved in social and political activities," he adds. "And they should not take over the function of politicians."

Reflecting on his experience as president, Katzir observes that for a while politics was "a new and somewhat bewildering world." But in the end he developed much more respect for politicians and their problems and accomplishments.

"Very often scientists or professional people underestimate the role of politicians in society," he stresses. "A scientist doesn't worry whether his solution to a problem is liked by people or not. Who cares? If it's the right solution, that's that.

"But for the politician, it's not enough to sit in his room and find the right solution. He has to find not the *optimal* solution, but a solution that will satisfy the people with whom he's dealing, who will be able to follow him."

Ironically, Katzir acknowledges, at a time when Israel is trying to build up applied R&D and science-based industry, there are three contrary phenomena: an anti-intellectual strain in Israeli society, a "flight from science" among Israeli youth, and a "brain drain" of scientists and engineers leaving Israel.

A number of observers have pointed to the existence of an anti-intellectual streak in Israel, which one might expect in a developing, somewhat rough-and-ready society that often trusts action more than words (similar, perhaps, to U.S. frontier traditions). Katzir agrees that there is such a streak. "It is always strengthened when the economic and social situation is bad [as it is now], because then people look where to cut the budget. And they always look with suspicion on people that don't produce something that one can sell."

However, he does not consider this a serious threat, because of two counterforces: The general tradition of respect for intellectual activities is "still very, very strong"; and R&D and higher education have so obviously helped to promote Israel's development.

By all accounts, Israeli youth is now in the midst of what one prominent scientist calls "a flight from science." In the past, science had high prestige and glamor for Israeli youth, but university science enrollments have generally dropped greatly in the past few years.

Katzir and other Israeli scientists cite a number of reasons for this phenomenon. For one, the wave of disenchantment with science and the anti-intellectualism that hit U.S. and European youth in the 1960's reached Israel, aided by disillusionment following the traumatic 1973 Yom Kippur War.

More important, job opportunities have declined and the pay of scientists is often relatively low. Basic research and teaching positions have closed up, but there apparently will be a gap of several years before new industrial R&D spots develop in sufficient number, level, and prestige. And Israel's small size means that it takes only a few scientists to saturate a specialized area.

Another and related problem is a growing "brain drain" of young Israeli scientists and engineers going abroad for graduate work or postdoctoral training and staying there. (In the past, Israel enjoyed a "brain gain," with a net influx of scientific talent.)

This "very serious problem" greatly concerns Katzir and other Israeli scientific leaders. "Good manpower, highly trained and creative people, is our main raw material in building up the country."

The only way to deal with this problem, Katzir notes, is to increase Israel's absorptive capacity by building up industry based on Israel's raw materials (such as Dead Sea salts and phosphates) and on know-how (particularly sophisticated, science-based industry). For example, when computer and electronics industries began in Israel a few years ago, Israeli experts who previously could not find suitable opportunities in Israel were attracted back. (Indeed, Frohman-Bentchkowsky views the U.S. as a "reservoir" for overflow of Israeli scientists who can come back, enriched in training and experience, to work in areas that will be important in five or 10 years.)

Part of Katzir's current scientific efforts, split between Weizmann Institute and Tel Aviv University, are expected to help increase scientific opportunities in Israel. At Tel Aviv, he is establishing a center for biotechnology, which will include work in fermentation, genetic engineering, and immobilized enzymes. He sees bright commercial potential for Israel in biotechnology. And at Weizmann, he is conducting basic research in three areas—structural fluctuations in biopolymers, the effects on living cells of modifying their membranes, and transport of oligomers and polymers into cells.

Israeli academic labs have developed a number of ideas that are arousing commercial interest, in some cases from foreign firms. For example, Yeda R&D Co., which carries out industrial applications of Weizmann Institute research, has formed a joint venture with Ares Co. of Switzerland, called Inter-Yeda Co. This firm is slated to start this summer to make fibroblast interferon by tissue culture on newborn human foreskins (using Israeli circumcisions as a source). There are also agreements with foreign firms for R&D on possible interferon production by several other methods, including use of recombinant DNA techniques.

Moreover, Yeda has a contract with Miles Laboratories for R&D on preparation of a thymus hormone, thymic humoral factor (THF), first isolated and identified by Weizmann scientist Nathan Trainin. Miles has invested more than $1 million a year for three years for work, mostly in Israel, focusing on production of more material and clinical tests. The hope is to use THF for treatment of diseases characterized by deficient immune mechanisms.

These and other Yeda projects fall into the area of biotechnology, notes Aharon Meytahl, managing director of Yeda. Some U.S. financial analysts believe biotechnology will take off in the next 20 years as computers or semiconductors have, he points out. "New biological materials like interferon will become the electronic chips of the future," he suggests. So Israel and Weizmann Institute are well positioned in the life sciences, he believes. Furthermore, he says, Yeda is now negotiating with some financial institutions about establishing a sizable company to work in biotechnology.

Another Israeli application of biotechnology involves experiments with algae. Koor Food Ltd. of Haifa, for example, has been licensed by Yeda to commercialize work begun by Weizmann scientists on a red single-cell organism, *Dunaliella bardawil*, that thrives in saline ponds. It produces about 40% of its dry weight as glycerol, and up to 8% beta-carotene. The residue then provides high-protein meal, and eventually may provide other biochemicals. Koor is building a pilot project—5 acres of ponds—near Eilat to test the process.

Another algal application is under development at the Technion in Haifa. This is a high-rate algal system for combined wastewater treatment and protein production, developed by a team led by Gedaliah Shelef. Algal use for sewage treatment also is being studied at other Israeli institutions.

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A third algal pond project is being done, of all places, in the heart of Israel's Negev Desert at Sdeh Boker, where Ben-Gurion University has its Jacob Blaustein Institute for Desert Research. The idea, according to Aharon Abelovich of the Applied Algology Unit, is to use brackish water ponds on arid land to raise algae as a protein source for animals and make this the basis of desert agriculture.

Abelovich uses a filamentous blue-green alga, Spirulina, which can stand high salinity (up to 10%). The system is a very efficient way of "harvesting light"—solar energy conversion—producing 8 kg dry weight per day on 400 sq m of ponds, two thirds of this protein. The possibility of extracting valuable chemicals from the product, as with Dunaliella, also will be tested. Several firms show commercial interest. (Other countries also are working on this alga, which has been used as food by tribes along Africa's Lake Chad and by ancient Aztecs in Mexico.)

Solar research in general, desalination, biomedical devices and instruments, and development of Israel's oil shale deposits are other active R&D fields. For example, in the solar area Ormat is preparing field tests of novel polycrystalline photoelectrochemical cells with liquid electrolyte developed at Weizmann Institute by Joost Manassen, Gary Hodes, and David Cahen, which have attracted wide commercial interest. And Renata Reisfeld of the Inorganic Chemistry Department at Hebrew University is cooperating with the U.S. Department of Energy and some U.S. firms in research on use of planar fluorescent concentrators to multiply the intensity of light falling on solar photovoltaic cells.

As Israel looks to future development of its science and technology and science-based industry, it faces many problems. One, according to Uzia Galil and David M. Vofsi, head of the Center for Industrial Research at Weizmann Institute, is insufficient entrepreneurial spirit. "To set up new industry, you need to take risks. People here are not willing to take risks," Vofsi notes. There are very few examples, he points out, of scientists who have left the laboratory to set up their own firms to develop their ideas.

Insufficient attention to the environmental effects of industrial development is another problem area. For example, Samuel J. Meltz of the Institute of Desert Research notes that there are plans to build a major center of chemical and petrochemical industry at Ramat Hovav, just 12 km south of Beersheba. Already, he notes, evaporative containing ponds

Israel-Egypt science ties: don't push too fast

Certainly the most dramatic event during chemist Ephraim Katchalski-Katzir's service as president of Israel was the visit to Jerusalem in 1977 of President Anwar Sadat of Egypt—the first such contact between Arabs and Israelis in three decades of conflict. As head of state, Katzir welcomed Sadat to Israel and rode beside him to Jerusalem, and he has since met twice more with the Egyptian leader and his advisers.

One particular question he discussed with Sadat was: Is Israeli-Egyptian scientific and technological cooperation possible, and how can it help to bring peace to the Middle East?

According to Katzir, Sadat's response in essence was, "Look, I don't understand science, but I know that it is important. In principle, I'll promote cooperation. But let's not push it too fast."

Thus, so far Israeli-Egyptian scientific relations have been unofficial and low key, involving get-acquainted private visits by a number of Israeli scientists to Egypt, conversations at international conferences in third countries, and a few visits by Egyptian officials to Israeli scientific institutions. For example, chemist Yael Allingham of Weizmann Institute made a private visit to the National Research Center in Cairo last May. There, she held "very open" discussions with some 15 senior scientists on parallel work she and they are doing on marine antifouling paints, environmental pollution, and corrosion.

Both sides have the same antifouling problems in the Mediterranean Sea, she notes. And both sides expressed hope of cooperating in the near future. The Egyptians said, "Just wait a little longer—we'll have a little more peace, and then we can have cooperation."

The general impression, therefore, is that of a "one-sided love affair," as one Israeli observer puts it, with Israeli scientists eager to start (and offering some specific proposals), while the Egyptians want a "gradual process." Apparently, establishment of scientific ties will require improved political relations between the two governments.

There are several scientific areas in which the two nations share common problems because of their common location and climate, and in which cooperation might be fruitful—for instance, agriculture, medicine, solar energy, oceanography, and desert research.

C&EN staff photo

Galil: more entrepreneurs needed

for effluents from plants on site are leaking, and chemicals are leaching laterally into a wadi (dry riverbed) nearby.

Moreover, Meltz points out, a national toxic waste disposal site has been started in the vicinity. His group is hoping to do a baseline environmental assessment before things get much further along.

No one can visit Israel without becoming forcibly aware of the tremendous burden that defense efforts place on Israeli society—in diversion of resources and manpower, in long reserve duty for able-bodied males, or in the eternal vigilance that is required to prevent a terrorist bomb from exploding in a bus, shop, or street.

This undoubtedly has restraining effects on development of science and technology, and science-based industry. However, several Israeli scientists point out that the effects are far from being all negative. For instance, Katzir and Pelah, both chemists long associated with Israel's defense R&D establishment, say that "an extraordinarily good group" of scientists has been built up there. And this has led to creation and stimulation of several sophisticated civilian industries, both through military contracts and spinoffs to civilian life of scientists and know-how.

So of these and many other Israeli difficulties that sometimes seem insurmountable, Mlavsky says, "It's hard to be competitive, but somehow the Israelis manage to be competitive. They're unrealistic in not being willing to accept the odds against them. But that's why they've achieved what they have." □

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